INDUSTRIAL LEAD POISONING.

ITS PREVENTION AND TREATMENT.

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by

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Industrial Lead Poisoning.

Its Prevention and Treatment.

The subject of Lead Poisoning is an old one, and an important one. It is of importance and interest to medical men because of the number of people who may and do become affected by it, and because of the diverse ways in which people are brought into contact with it and so rendered liable to come under its baneful effects. It interests us from a medical point of view mainly under two headings;-

1. Clinical.
2. Legislative.

Under the former we are brought face to face with it, as it exerts its hurtful influence on human beings, and as a disease we have to recognise its signs and symptoms and treat the condition, under the latter we have to study it in its relation to Preventive Medicine, and take such steps as may prevent it entirely, or reduce the number of people becoming affected by it.

Among the metallic poisons Lead is the one above all others which most affects individuals, this being due to the wide use to which Lead and its compounds are put. Our drinking water is often stored in lead lined cisterns and is conveyed throughout our houses

in lead pipes, we cook our food in lead enamelled vessels, our houses are partly decorated by painting with lead compounds,and we use lead so much in the arts and in the manufacture of various articles of commerce, that people are brought into contact with it in a great variety of ways.

In 1896 the first Act of Parliament came into force making it obligatory to notify all cases of lead poisoning, the onus of doing so falling on medical men and the occupiers of factories, and our statistics of such cases date from that period.

Tanquerel Des Planches' "Traité des Maladies de Plomb ou Saturnines" gave us the first full clinical description of lead poisoning, and his accounts of the signs and symptoms of the disease has become quite classical, and even up to the present day very little has been added to our knowledge of the disease, that is not contained in that wonderful treatise.

Sir Thomas Oliver of Newcastle-on-Tyne has largely helped to attract attention to the subject in recent years by his work and writings on it, and the several enquiries held from time to time by Departmental Committees appointed by Parliament in connection with the manufacture of white lead and the use of lead in the earthenware and china industries has brought the subject into greater prominence and shown that it has been

in no small numbers that lead has affected those brought into contact with it, and that the mortality is a very high one in those occupations engaged in the manufacture of the various compounds of lead, and in those such as painters, plumbers and glaziers in which some of the lead compounds are used.

It is a subject of importance, too, because of the slow and insidious way in which lead often attacks an individual, allowing the poison to do a good deal of damage to the tissues of the body before it is recognised, andon account of this tendency and the frequent failure to recognise these early and incipient cases, and the disastrous effects it has upon the human economy, it behoves us as far as possible to use every endeavour to prevent its entrance into the body, and when this has failed and entrance has been gained, to be able to recognise that fact as early as possible and then take steps to curtail its harmful effects by assisting the person to get rid of it.

For the past ten years I have assisted in the medical supervision of the employees of the "Tyne Lead Works" owned by Messrs. Foster, Blackett & Wilson at Hebburn-on-Tyne. At these works was carried on the desilverising process, the manufacture of white lead, red lead, sheet lead and lead piping. About two years ago, the desilverising and manufacture of white lead

(which was done by the old Dutch process) was stopped and the number of workers has consequently diminished. Nine years ago there were employed at this factory about 140 men and about 30 women, today with the white lead making non-existent there are employed about 80 men and 6 women. My duty in connection with the factory has been to assist at the weekly inspection and examination of the employees, in order to detect any incipient cases of poisoning, and also to treat any cases of intoxication by the metal that might arise.

In the present thesis I propose to treat generally the subject of Industrial Lead Poisoning, basing the work on my experience during the last ten years at the Tyne Lead Works.

HISTORICAL OUTLINE.

The deleterious effects of lead have been long known. Historians tell us that the working of mines, smelting, purifying and working of metals was known to the ancients. Amongst them the art of painting and decorating was widely cultivated and white lead as a paint and colour would not be the last to become known to them, and the fact that they made use of it would mean that they would not escape from its baneful effects any more than we do now.

Hippocrates is said to have described lead colic and to have recommended the salts of lead for the treatment of haemorrhage.

Nicander before the Christian era in his works described fairly accurately an attack of acute lead poisoning caused by the introduction of lead into the stomach. He says, "Soon after litharge or white lead has been taken internally the person becomes constipated, wind accumulates with noise towards the middle of the belly and in the umbilical region. This causes the most excruciating pains as bad as those found in the most obstinate colic. The invalid passes less urine, he feels a burning heat in his limbs, his colour becomes of a leaden hue". Under white lead the same author also mentions about paralysis caused by lead taken into the stomach; "The man thus tortured

and broken down, finally loses the power of his limbs which decay".

Celsus recognised the dangers associated with the administration od lead preparations, and recommended that those who had swallowed white lead should be made to vomit.

Dioscorides gives both a description of lead colic and its treatment.

Galen in his "De Medicina" mentions that it caused a kind of dysentery when it got into the stomach by drinking water that had been carried through lead pipes.

Lead was forbidden to be used for conducting water in Rome during the time of Caesar Augustus and on the Continent lead was very little used by the ancients who constructed their reservoirs of marble or cement and their domestic utensils of copper or pottery.

Paulus Egineta, Rhazes and Avicenna give accurate descriptions of lead poisoning, and all note particularly the symptoms of constipation, colic, coating of the tongue, supression of urine and the paralysis of the limbs.

In 1767 Sir George Baker drew the attention of the medical profession to the production of Colica Pictonum by the drinking of cider which had become contaminated with lead in its manufacture.

In more recent times much valuable work has been done on the subject by workers on the Continent and in

this Country, chief amongst the latter being Oliver, Legge, and Goadby. They have performed many interesting experiments with lead in different forms (chemical and physical), from which much information has been gleaned and help in the treatment of lead poisoning obtained. By means too, of the various Enquiries and Reports of the Departmental Committees appointed by Parliament, much detailed knowledge regarding the methods of work in lead compounds in different industries in which they are used has been collected, throwing prominently into view the sources of danger to which the workers are exposed and thereby pointing the road to means of protection from these dangers.

Lead, however, would have a much smaller sphere of usefulness in ancient times compared with the present, and cases of lead poisoning must be very much commoner now than then.

CHEMISTRY.

Occurence;- Lead has been foundin small quantities in the uncombined state, probably reduced from its ores by volcanic action. It is, however, as Galena, where it is combined with sulphur, that it is found in great quantities, andit is from such that the metal is chiefly obtained. It is also found as the Carbonate (Cerrusite) and to a smaller extent in other natural compounds. Because it is very easily reduced from its compounds it was one of the earliest known metals.

Properties. Lead is a soft bluish-white metal which shows a bright metallic lustre when freshly cut, but on exposure to the air becomes dull by the surface becoming covered with a film of oxide of lead. Lead is soft enough to be easily scratched with the finger nail and leavesa black streak when drawn across paper.

It is readily dissolved by Nitric Acid, but scarcely at all by Hydrochloric and Sulphuric Acids in the cold. It is unacted on by pure water in the absence of air, but in contact with air, lead hydroxide is formed which is slightly soluble in water. The solvent action of water is greatly influenced by the presence of various dissolved substances - ammoniacal salts or Carbonic Acid increase its solubility, while phosphates and carbonates reduce the solubility to practically nothing.

Lead has a Specific Gravity of 11·3 and melts at 330°-335°C, at which temperature it becomes covered with a black film of the suboxide (Pb_2O), when more strongly heated it is oxidised to the monoxide (PbO).

Several oxides of lead are known, the ones of chief interest to us being the protoxide hydrate and bioxide, massicot and litharge. Among the lead salts of chief interest are ;-

1. The Acetate, basic and normal, which are met with as intermediate stages in the production of white lead from metallic lead.
2. The Carbonates or Hydrated Carbonates in which form, lead is most widely used, and by which it gives rise to most cases of poisoning.
3. Lead Chromate used as a pigment.
4. The Silicates, Silico-borates and Silico fluoborates which are employed in the manufacture of glazes and enamels used in the potteries and for many kinds of glass and crystals.
5. The Nitrates and Chlorides, the latter being used in plumbing, soldering and tinning of metals.

These compounds embrace the chief ones employed commercially, and as such are the ones giving rise to the injurious effects of lead, some of them doing so to a greater extent than others, depending on the extent to which they are used and also to the solubility and

readiness with which some are absorbed over others.

The Industries in which Lead Poisoning occurs.

Lead is used in so many industries at the present time, and these industries are so varied, and often have so little in common, that it will be well to tabulate the more important ones, and for this purpose I will take the table of the Chief Inspector of Factories in his last Annual Report (1913) and with it give the number of cases of plumbism notified to the Home Office during the year 1913 in each of these industries.

Annual Report of Chief Inspector of Factories

Industry	Reported Cases 1913	Deaths 1913
1, Smelting of Metals	26	3
2. Brass Work	10	-
3. Sheet Lead & Lead Piping	7	-
4. Plumbing & Soldering	34	1
5. Printing	21	1
6. File cutting	14	-
7. Tinning	9	-
8. White Lead	29	2
9. Red Lead	7	-
10. China & Earthenware	62	11
11. Litho-transfers	1	-
12. Glass cutting & polishing	3	1
13. Vitreous enamelling	9	-
14. Electric Accumulators	44	-
15. Paints & Colours	22	1
16. Coach Building	71	2
17. Ship Building	31	1
18. Other Industries	86	1
19. Paints used in other Industries	49	3
Total reported cases of Lead Poisoning for the year 1913 ,,		535
Total deaths from Lead Poisoning for the year 1913 ..		27

The above list brings out in a marked manner the variety of occupations in which lead in one form or another is used. I will now proceed to take up each industry by itself, and briefly go into the way in which the worker is brought into contact with the lead or its compounds in each industry.

Lead Mining. This industry - a very old one - is now in Great Britain confined to the South of Scotland, North of England, and Derbyshire. The lead in these districts occurs as Galena - the pure metallic form- and cases of lead poisoning in miners is extremely rare, due to the fact that Galena is insoluble..

Lead Smelting. This, the next stage in the treatment of the lead ore, is the first one in which lead poisoning shows itself prominently. The smelting of the ore is done by several processes, but in all of them there is the danger of fumes given off from the molten lead in the furnaces reaching the workers, in some cases accidentally as from the furnace fronts, and in other cases unavoidably. From the furnace the smoke and fumes are carried into flues which are so constructed that the smoke has to travel along these flues for perhaps a mile, and then into a chimney from which the fumes escape into the air, and becoming dispersed by the wind currents over a wide area, are rendered more dilute. The dust which accumulates in the flues con-

tains much lead (15-30 per cent) as a fine powder, and in cleaning out these flues which is done periodically the workers are apt to suffer from plumbism from absorption of the dust.

Brass. Lead enters into the constitution of brass, and the workers in brass suffer occasionally from plumbism, (1) as a result of the fumes in casting the brass, (2) as a result of the dust given off in polishing it, and in the case of chandelier fitters, through them putting their mouths to the open end of the tubing to blow through it for the purpose of testing the joints.

Sheet Lead and Lead Piping. In these industries lead poisoning rarely ever occurs. The clean metal does not seem to readily give rise to bad effects when handled, and where cases of plumbism have occurred they have usually been due to the fumes given off from the melting pot which is the preliminary stage of pipe making.

Plumbing and Soldering. In the Government Report the statistics for lead poisoning under this head include all persons handling white or red lead paste and those employed in soldering and lead-burning - excepting house plumbers who are included with house painters. In the former the worker may be brought into contact with lead dust in making up the paste, and in the latter it is due to the fumes given off which chiefly give rise to

plumbism. Considering the large number of workers engaged in this class of work it is surprising that the cases of lead poisoning are so few among them.

Printing. This occupation as a source of lead poisoning is of much less importance than it used to be since the increasing use of sterotyping and linotyping is displacing printing by hand. Machines now set the type automatically. Type metal is an alloy of lead three parts to antimony one part, and the workers in the printing shops are brought into contact with lead fumes at the casting pot or lino melting pot, also in handling the type, and in the dust set up in the general wear and tear of the type by handling and knocking about in the boxes. The dust in printing shops has been shown to contain as much as 14 per cent of lead (Oliver). The effect is further increased owing to the hot, close, stuffy atmosphere of most workshops.

File Cutting. Lead poisoning from this source is becoming a diminishing quantity because the old hand method of cutting files is being gradually superseded by machinery. In the old hand method the worker embeds the file on a sheet of lead and with a hammer and chisel he makes the lines on it, doing first one side and then turning it over does the other. A considerable amount of fine dust is given off, and the operator leaning over his work cannot help but inhale

some of it. Dust from a file cutting workshop has been known to contain from 2·64 to 4·37 grs. per 100, (Oliver - Diseases of Occupation). In the hardening of files, they are put into molten lead till they become red hot, and the fumes from the molten mass of lead cause occasional cases of lead poisoning.

Tinning. In the tinning of hollow ware such as pots and pans, the utensils are first cleaned with Hydrochloric Acid and then dipped into a bath of molten tin and lead (lead about 40%, tin about 60%), though owing to the greater cost of tin this proportion sometimes becomes reversed. The workers employed in dipping the ware may become affected by the lead from the fumes, chiefly chloride of lead, and the users of the ware, especially the cheaper ware which contains a greater proportion of lead, and because of its cheapness this applies more/to the poorer classes of the community, may become contaminated with the lead by it being dissolved out in the act of cooking and so getting into the food.

Desilverising. This is chiefly done on Tyneside by the Pattinson process, which was first introduced here, and is based on the fact that pure lead crystallises out at a higher temperature than an alloy of lead and silver, and the process is done in order to separate the silver which is often present in variable quantities

in most lead ores. The mixture of lead and silver is put into one of a series of pots and melted by heat. It is then gradually allowed to cool, and in cooling it is constantly ladled by a workman with a sieve ladle, who ladles out the crystals of lead as they form into the next pot on his right. This is again melted and again the lead as it crystallises out in cooling is ladled on to the next one and so on. In this way the last pot of the series contains pure lead with no silver.

In the other process, that of Parke's, zinc is added to the mixture of lead and silver and all melted. When cooling occurs an alloy of zinc, silver and lead is formed as crusts which when broken up and subjected to a high temperature allows the zinc to be driven off. What is left, and also in the Pattinson process the contents of the first pot (containing much silver and little lead), is now cupelled, the lead being converted into oxide of lead which melts and is run off leaving the pure silver behind as it is not oxidisable.

In the Tyne Lead Works of Foster, Blackett and Wilson cases of plumbism from desilverising were very rare, and were due when they did occur to the fumes given off from the molten metal being inhaled by the workers.

<u>White Lead or Carbonate of Lead</u> is produced in several ways, the two chief ones, however, being

1. The Dutch Process.
2. The Chamber Process.

In the Dutch Process, which is a very old one, a series of chambers or "Stacks" are built in a row alongside each other. About 25 feet high, they have a wide opening or door running from the floor to the top for the passage in and out of the workers. On the floor of this "stack" a layer of spent tan is placed, and upon this is set a layer of earthenware pots partly filled with dilute acetic acid. Over the tops of these are placed strips of perforated lead, called "grids". On top of these is placed a layer of wooden planks, then again a layer of tan, acid pots and lead and so on till the "stack" is built up to near the top, the doorway being built up by planks as the work proceeds. These layers are called the "Blue beds", and the "stack" thus completed is left for about 4 months. During this time the tan undergoes fermentation and the temperature rises to about 60°C - 70°C, and much Carbonic Acid gas is evolved. The Acetic Acid is vaporised and attacking the lead converts it into acetate of lead, and the Carbonic Adid gas acting on this acetate converts it into Carbonate of Lead. At the end of the 4 months the "stacks" now formed of what are called "White Beds" are taken down, and the Carbonate of Lead is taken away to a series of rollers where it is crushed and washed in order to separate any pieces of uncorroded blue lead. The white lead is now ground to a pulp and then taken in shallow pans to be dried in the ovens or "Stoves" (a room with a series of

shelves on which the pans are placed, and heated with steam pipes). When dry this powder is packed into barrels in the dry state or mixed with linseed oil and made into paint.

The building up of the blue beds is comparatively speaking not dangerous and women are allowed to do this, but the taking down of the white beds is very dangerous and women are prohibited from this work by the Home Office. Much dust is given off in handling the strips of white lead, and the same happens though even to a greater degree in removing the dry product from the stoves and in packing it dry into the barrels.

The Chamber Process is not quite so common as the Dutch. In this method strips of lead are hung over a series of bars in a chamber which is then closed and Carbonic Acid gas and hot acetic acid are driven into the chamber through pipes.

The same chemical changes take place as in the Dutch Process, but in less time, as the corrosion is complete in about 2 months. Then the passage of the acetic acid and carbonic acid gas is stopped, and steam is passed through instead, to moisten the material, and then men go in and remove the Carbonate of Lead, when it undergoes much the same processes as described in the Dutch method after it leaves the "White Beds". This process is not quite so dangerous as the Dutch Process, but it is said to make an inferior quality of white lead.

Red Lead.

This is formed by placing pure pig lead into a reverberatory furnace, heating it to a dull red heat and keeping it stirred about by a long handled rake through the furnace door. Oxidation to lead oxide (PbO) or massicot thus takes place. This is washed and dried/again heated at a rather lower temperature than at first when further oxidation converts it into Red Lead.

If the mouth of the furnace is not well hooded and supplied with a good graught, the fumes may come out on to the workmen, or again when raking out the finished product clouds of red dust may arise and be inhaled or swallowed by the operators, and the same may happen when packing it into barrels. Compared however with the manufacture of white lead, the making of red lead is not nearly so dangerous.

China and Earthenware. In the manufacture of china, earthenware, sanitary ware, tiles, etc., which constitutes the British Pottery Industry (the centre of which is Staffordshire with about 50,000 employees) there are generally two component parts;-

1. The clay body.
2. The glaze.

The substance known as the "body" is composed of some kind of clay, unmixed or mixed wih other ingredients and is porous, being therefore unsuitable for

holding liquids. To overcome this porosity an impervious material has to be coated over the 'body' and this layer is known as the 'glaze'. This 'glaze' is formed of lead compounds, and besides rendering the article impervious, also gives it the smooth glass-like finish. In the work of glazing the 'body' is first fired, then dipped into a liquid glaze which may contain lead in the form of Carbonate of Lead, or the lead may be mixed with other substances, viz;- silica, boric acid, etc., which has been subjected to a high temperature and vitrified. The dipped article is then dried, smoothed and cleaned and then again subjected to a high temperature which melts the glaze and gives when it cools the smooth glossy appearance seen on all such ware.

It is in the dipping, and more so in the cleaning and smoothing of the dried glaze that the workers inhale some of the dust given off in the operation, and expecially when the unmixed or raw lead is used. The mixed glaze or "fritted lead", which is extremely hard and only very slightly soluble in acids, is much less dangerous. Nevertheless a large number of the workers annually suffer from lead poisoning and most of the deaths from that cause occur in the potteries.

Litho-transfers. This work consists in the application to earthenware and china of various coloured decorations, and this is done by dusting on to the pattern on the article the enamel colours which contain

much lead, and to this and to the sometimes frequent necessity of cleaning the machines in changing the colours, the cause of the few cases of plumbism met with in this industry can be attributed.

Glass Cutting, Etc. In the manufacture of glass much red lead is used, and in mixing it with the other ingredients the dust given off has caused plumbism.

In the polishing of cut glass a paste containing 71% of oxide of lead is used on a wheel or brush revolving at a high speed, and the dust from this thrown off into the air of the room likewise gives rise to lead poisoning.

In diamond polishing the diamond is embedded in an alloy of 60% of lead and 40% of tin forming a knob about the size of a walnut. The polishing is done by a wheel rotating at over 2000 revolutions per minute. Thus from contact with the lead in fixing the diamond, and from the dust given off in polishing, lead poisoning is apt to be set up in the workers.

Enamelling of Iron Plates and Hollow Ware. The enamelled plates now largely used for advertisement purposes are mostly made in the "Black Country" - Birmingham, Wolverhampton and surrounding districts. In their manufacture the plates are first cleaned, then smeared with a gum solution, and lastly dusted over their surface with a powder or liquid containing metal-

lic dust. This powder may contain as much as 20% of a fritted lead. The plate is now exposed to a high temperature in an oven for a time and then cooled. The various colours are now painted on with brushes and allowed to dry. All letters, figures, etc., are then formed by placing a stencil with the letters or figures cut out in it, over the plate, and the dried surface paint is then wiped off by women and girls, over the parts of the plate exposed through the cut letters etc. of the stencil.

As a result of this latter operation much dust is given off which contains various quantities of lead, and if this dust is not carried away by a powerful down-draught (which is usually employed), some of it rises upwards and is inhaled with the resulting production of lead poisoning in the employee thus exposed to it.

Red lead and other lead compounds are largely used in this enamelling process and are often present in the powder or solution to the extent of 25-30%.

Baths and other enamelled hollow ware go through much the same process as the above, and have the same associated dangers.

Electric Accumulators. In this industry for the making of secondary batteries lead plates are cast from moulds and into the interstices formed in them, is "pasted" a mixture of red lead and Sulphuric Acid. A number of these are connected together as positive

plates and a number as negative, and the connections are made with an oxy-hydrogen blow-pipe. These are then put together into batteries by fastening "lugs" to each plate and connecting these by a bar of lead which is burned on.

The melting down of old plates and the casting of new ones allow of fumes to be given off, and in the mixing of the red lead and Sulphuric Acid, and in "pasting" up the interstices of the plates dust from the dried paste gets into the air, while in assembling the plates fumes are given off in burning by the blow-pipe flame, and to these fumes, and to the dust and the handling of the plates must be attributed the number of cases of plumbism which yearly arise in this industry.

Paints and Colours. In the manufacture of paints (chiefly white paint from white lead as this also forms the basis for other colours), the chief danger is in opening and emptying the casks of dry white lead, and in delivering it to the mixer, when lead dust may get into the air around the worker.

Colours used in dye works include yellow, which is got from chromate of lead and the workers (women), who handle the wool, get covered with the yellow powder.

In Calico printing lead salts are also used to colour the calico, and here it is in the drying rooms where much dust is given off in handling the dried goods, and being inhaled or swallowed causes trouble.

Painting. In house-painting the workman is brought into contact with lead in several ways. In burning off old paint lead fumes are given off, and in smoothing with sand-paper the old painted surfaces, or surfaces which have received a prime colour, or where puttying has been done with white lead, much dust containing lead is given off. Also paint getting on to the hands may be absorbed through cuts and cracks in the epidermis, or from unwashed hands be swallowed when partaking of food.

The same applies to coach and motor car body painting, though here the dust, caused by sand-papering the dried paint, plays a more important part, since a coach or motor carriage will be painted as often as ten to fifteen times and sand-papered as often, before receiving its coat of varnish.

Many workmen and much paint is used in finishing a ship, and the same dangers are run by the workers as in the case of house painters.

Other Industries. Under this head comes a series of industries, chief among which are the making of shot, manufacture of indiarubber, lead capsules for bottles, tempering of buffer springs, lining boxes with sheet lead, etc., and in nearly all these the evil effects of the lead are brought about by dust or fumes at some part of the process in their manufacture.

Symtomatology. All the industries enumerated above being associated with lead in one form or another provide cases of lead poisoning. Such cases of Plumbism vary in number in these different occupations according to the part, important or otherwise, that lead plays in them, and according to the number and character of the precautions taken to prevent them. Among these industries, important as causing a big percentage of cases of Plumbism, are those concerned with the manufacture of White Lead and Red Lead - processes carried on at the Tyne Lead Works of Messrs. Foster, Blackett and Wilson. In addition to these they make Lead Pipes and Sheet Lead, and for the past 6 months have also been engaged in the manufacture of rods of a compound containing a large percentage (98%) of lead for the making of rifle bullets. Even in these industries of white and red lead manufacture however, the percentage of cases of Plumbism has steadily declined in later years, as shown by the following statistics taken from the Annual Report of the Chief Inspector of Factories and Workshops up to the year ending 1913 :-

1900	1901	1902	1903	1904	1905	1906	1907
1058	863	629	614	597	592	632	578

1908	1909	1910	1911	1912	1913
646	553	505	669	587	535

Lead Poisoning may arise as the result of :-

1. One or more large doses of lead taken into the body.
2. Small but continuous absorption of soluable lead salts over a period of time.

The first is the less important of the two. It gives rise very soon to the acute symptoms of the disease, causes the patient to seek immediate relief and as a rule under treatment he quickly recovers and sustains no permanent damage.

In the second form, however, it is of greater importance, because here the damage to the tissues may go on insidiously, without the patient becoming aware of it, till when he does recognise that something is wrong the effects of the lead on his tissues may be such that complete recovery is impossible, in fact it may ultimately be the indirect or even direct cause of his death.

In both forms the train of symptoms of lead poisoning is the same, viz: Saturnine cachexia in which the face of the worker becomes pallid and expressionless, the eyes become dull and the conjunctivae take on a dirty yellow colour, a sweetish metallic taste develops in the mouth, the breath assumes a disagreeable odour and a blue line develops on the gums, there are frequent headaches, constipation becomes more and more obstinate (in a few cases there may be diarrhoea) and then suddenly there comes on severe colicky pains in the abdomen with vomiting, slow high tension pulse, and a scanty

flow of high coloured urine. Such in brief is the clinical picture of the cardinal symptoms presented by a typical case of Acute Lead Poisoning. In a more chronic form lead when absorbed may have a detrimental effect directly or indirectly on the tissues of the Nervous System, the Liver, Kidneys and Arterial System. Acute Lead Poisoning due to one or two large doses of lead is not of frequent occurrence and is usually due to swallowing some of the soluble lead compounds (a) by accident, (b) to produce abortion or (c) with suicidal intent. Industrially it rarely ever occurs and the few cases of it that have been reported have been due to accidents, such as falling into a tank of some solution of lead. The form in which it is commonly found is the more or less chronic one in which the lead has been absorbed in small quantities over a lengthy period and giving rise to the symptoms enunciated above. These symptoms appear very much in the order named, but a lead worker may show a number of these symptoms without actually suffering from lead poisoning, that is to say, he is still capable of performing his usual day's work and technically and legally is not suffering from lead poisoning, in fact quite 90% of those employees who have worked for any length of time in a lead works will show certain of these signs such as the cachexia and blue line on the gums, and at the Tyne Lead Works out of 100 employees I have counted only seven or eight who did not possess

a blue line, and still they were all quite fit to do and were doing their ordinary work. What such signs show is that these persons are absorbing lead into their systems, which absorption may go on for an indefinite period before they may actually suffer from lead poisoning incapacitating them from work. This is an important fact from a medico-legal point of view since a person may show signs of Lead Absorption without suffering legally from Lead Poisoning.

Taking the various signs and symptoms individually and going into them in detail we come first to

Pallor of the Face. This is one of the earliest signs that a person exposed to the influence of lead shows as a proof that lead is being absorbed and retained in his tissues. It is very characteristic of lead toxaemia, and with it the worker's features also change, the face becomming thinner and expressionless. The pallor is especially obvious in those workers who, naturally fresh coloured, commence work in a white lead factory and are absorbing small quantities of lead.

With the pallid features is soon associated a dirty yellow colour of the sclerotics of the eyes, and a paler appearance of the vessels of the conjunctivae. All this is due to anaemia, the result of the destruction of the red cells of the blood. The red cells become reduced in number and their haemoglobin content also becomes reduced. Their number decreases owing to red cell destruction and it is the pigment from the broken

down cells that gives the yellow pigmentation to the otherwise white sclerotics. There is also a general loss of fat and weight, and the loss of the subcutaneous fat gives the face the fallen in and pinched appearance it assumes.

The Blue Line is found at the margin of the gums close to the teeth. If on one gum only it is usually that of the lower jaw, if present on both gums it is more marked on the lower gum.

There are two quite distinct blue lines. The one is found along the edge of the gums and up between the interstices of the teeth. It is outside the mucous membrane of the gums, and by the frequent and vigorous use of a toothbrush is easily removed. I have found it repeatedly on the gums and between the teeth of artificial dentures in lead workers. It is caused by lead, such as white lead dust, deposited on the outside of the gums and between the teeth, the lead being converted into lead sulphide by sulphuretted hydrogen given off from decomposing food lodged between the teeth. It may be found after a person has been exposed to lead dust for a few hours.

The true blue line or Burtonian line is quite a different thing, the lead in this case being underneath the mucous membrane of the gum, and it cannot be removed by the mere use of the toothbrush. This true blue line is always found in association with decayed teeth and with gums that are ulcerated and ragged with a

certain amount of inflammation(gingivitis) bordering the ulceration. On viewing this line with a pocket microscope it is seen to be punctated.

Fagge in his "Principles and Practice of Medicine" attributed this line to lead that had been absorbed into the blood from the stomach and thence carried to the mouth where it met with sulphuretted hydrogen, became converted into black lead sulphide and was then exuded from the smaller bloodvessels into the surrounding tissues of the gum,while some remained in the small bloodvessels.

This may take place to a small extent but the more likely way of production of the blue line is by direct absorption from the mouth into the tissues of the gums. As stated above wherever the Burtonian line is found, there also exists ulceration of the gum margins,and particles of lead dust,becoming deposited on the raw ulcerated surface,become absorbed by phagocytic leucocytes which carry them into the lymphatics and deposit them in and between the tissue cells of the gums. This can be proved by microscopic examination of sections of gum containing the true blue line, when the particles of black sulphide of lead are found, not in the small bloodvessels, but in the small lymphatics and in and between the tissue cells of the gum. It is only where the surface of the mucous membrane is broken that this true blue line is found, and where the teeth are kept clean or where the teeth are absent, and the gum mucous

membrane is intact it is not found. One of the workers at the Tyne Lead Works, by name, A. Stone, pays much attention to his teeth which are all sound and good and has no evidence of a blue line, though he works in the stoves for months at a time. On the other hand by painting the gums with Liq. Plumbi Subacetatis of a person not a lead worker and who does not keep a clean mouth a blue line is soon developed. Additional evidence that the blue line is formed in this way is found in the occasional appearance in some workers whom I have seen of black or blue patches on the inside of their cheeks, at the level of the teeth. I have invariably found that this black patch or blue patch was opposite a decaying, rough, jagged tooth or where there had been one, and the tooth, coming into contact with the mucous membrane of the inside of the cheek, had irritated and broken it and caused a small ulcer, and particles of lead sulphide had been absorbed from this ulcerating surface and had been deposited immediately underneath it, as in the case of the ulcerated gums, and on section, again the particles are found deposited in and between the tissue cells and in the small lymphatics. Exactly the same condition is found in those dark patches occasionally found in the large intestine of lead workers post-mortem, but here the source of irritation has been scybalous masses of faeces lying in the intestines, causing a breach in the mucous membrane followed

by absorption of lead converted into lead sulphide by the sulphuretted hydrogen in the intestine.

Similiar lines on the gums but of a different nature may be found in men who work in other dusty processes. Thus those employees who work among the bark used in the manufacture of white lead acquire a brown line in place of the blue one, which is caused by a deposit of the fine dust from the bark. Also workers apart from lead may show characteristic lines on their gums - black in coal miners, and greenish blue in copper workers.

Constipation. When a worker is failing to excrete lead pari passu with the absorption of it, he is on the high way for an attack of lead colic and in most cases this attack of colic is preceeded by a period of profound constipation. This acts in a vicious circle, because the intestinal canal bing one of the paths for the excretionof lead from the system, the retention of lead in the bowel increases the constipation, and the increased constipation increases the balance of lead retained in the bowel, and consequently increases the absorption of lead into the tissues and so hastens on the attack of lead colic.

Lead Colic. Up to this point all the preceeding signs and symptoms may be present in a lead worker without causing him any great inconvenience, certainly without causing him to cease working. They merely show that the individual is coming under the influence

of lead, that it is being absorbed into his tissues and that it is causing certain changes in the tissues, but the man may be quite fit for his work, he will say that he feels nothing wrong with him, and he does not actually go on working. Medico-legally he is not considered to be suffering from Lead Poisoning, and at least 90% of the workers in all lead factories will show the above signs and symptoms to a greater or less degree.

The onset of abdominal colic, Hunter's "dry-belly-ache", however, is the commonest symptom, showing that the patient is suffering from Lead Poisoning, and it is the commonest symptom which makes the worker cease his work and seek relief.

During an attack of colic the patient cries out with the severity of the pain, is covered with a cold perspiration, lies with his legs drawn up or rolls about the bed. The pain comes on in spasms, being intermittent in its exascerbations, sometimes very severe then easing off without entirely disappearing and then coming on severely again. The abdomen is retracted and the patient locates the pain at the lower part of the abdomen or in the neighbourhood of the umbilicus, and he often obtains much relief from pressure on the abdomen, so that he may be found pressing the abdomen on a pillow over a chair back, or pressing his thighs into his abdomen. The patient often vomits. On pressing the fingers into the abdomen I have often found a line of greater tenderness running along the

left side of the middle line especially over the descending aorta.. The body temperature is slightly lowered and the pulse is markedly slowed down (I have foundit as low as 40 per minute) and presents a very high tension, 140-170 m.m. of Hg., this being especially marked during the paroxysm of pain. He wishes to go frequently to stool, but invariably he passes nothing but a little mucus or blood. The urine becomes scanty and high coloured. The pupils of the eyes often show inequality during this colic stage.

Such is the condition in which one finds a patient who is suffering from Lead Colic, but ill as the patient may appear, it is rare that he dies from acute colic.

The cause of the colic is one about which there is still uncertainty. A number of investigators have found various degenerative and cirrhotic changes in the gastric, intestinal and allied organs (liver, spleen and peritoneum). Oliver in his book on Lead Poisoning 1891, states that he found in a guinea pig which had lead mixed with its food,"the small intestine in a state of varicosity, portions of normally distended intestine alternating with other portions so extremely contracted as to have their calibre almost completely obliterated and the piece as hard as whipcord", and he believes that this stricture, was due to the extreme shortening of the circular muscular fibres of the bowel, gives rise to the colic by pressure upon the nerves,

together with the efforts of the distended portions of the bowel trying to propel their contents into the contracted parts below.

Other workers, Legge and Goadby (Lead Poisoning and Lead Absorption) attributes it to contraction of the bloodvessels in the splanchnic area,and support their views by the fact that vaso-dilators such as chloroform, amyl nitrite, nitro-glycerine, and atropin relieve the colic. They showed, in a series of clever and lucid expriments on cats, as one of the constantly recurring effects of lead on the tissues, minute haemorrhages which occurred in various parts of the body, but especially in those parts which showed the burden of the poisoning in life, viz:, in the brain and nerve tissue in encephalopathy and paralysis, in the kidneys in nephritis, and in the liver, spleen, heart and lungs.

It seems to me very probable that lead has a marked tendency to act on unstriped muscle fibre, irritating and stimulating it to contraction much in the same way as alcohol does. While circulating in the blood it causes contraction of the arterioles,and the circulating lead,like alcohol,when in small quantities over a long period,will cause through the prolonged irritation and contraction,degeneration and arterio-sclerosis of the vessel walls as is found in such cases, and in the acute forms with larger circulating quantities, it will give rise to the greatly increased arterial tension with slow pulse,as is found in cases of colic, and this

in turn is the cause of the minute haemorrhages. In the same way acting on the unstriped muscle fibres of the intestine, and causing the irregular contraction of the intestine, it gives rise to the colic in those particular cases.

Certain it is that one of the primary and constantly occurring effects of lead on the system is on the blood and bloodvessels, and accumulating evidence goes more and more to show that very many of the signs and symptoms of lead poisoning, and many of the pathological changes caused by it, are traceable directly or indirectly to the changes it produces on the blood and bloodvessels.

The Nervous System. Lead affects the central nervous system by occasionally producing in a lead worker acute enceph al~~itis~~opathy. When it does so, it usually comes on rapidly and often proves rapidly fatal. The patient complains of severe headaches for a few days, then may take an epileptiform fit and becomes unconscious, developing rapidly into coma and death. It is the most dangerous form of Lead Poisoning.

The Paralyses have always come under the heading of the Nervous System, as a chronic toxic effect of Plumbism, but it is questionable if this is correct, because it is becoming more evident that the muscular paralysis found in Plumbism may be as much due to the effect of lead on the muscles themselves through their blood supply, as to the effect of lead on their nerve

supply. It has generally been thought that the cause of the muscular paralysis - the loss of power and wasting - found in some cases of Lead Poisoning was due to the evil effects of the lead salts on the nerves, as also it was stated that lead had a selective action on certain nerves, such as the musculo-spiral, because in the commonest form of paralysis the muscles chiefly affected were the extensors of the wrist and fingers, the lumbricales and interossei and the muscles of the thenar and hypothenar emminences, all supplied by the musculo-spiral nerve, and what was considered further proof of this, was the fact, that the Supinator Longus which received in addition to its supply from the musculo-spiral, branches from the Median Nerve, escaped paralysis. This selective action of lead has been shown by several investigators, viz:, Edinger, Teleky and latterly by Legge and Goadby to be correct and not so far as the nerves are concerned as the muscles themselves, and that the real determining factor is the use the muscles are put to. Thus those muscles which have the greatest strain thrown on them and which are not quite capable of coping with that strain, are the muscles which exhibit the loss of power and paralysis, and it has been shown by these investigators that in different trades and occupations a different series of muscles may be affected, according to which muscles are most used by the workers, and of course including with the

muscles the nerves supplying them. When one considers the effects of lead on the bloodvessels as shown histologically in the experiments of Legge and Goadby one can understand what these investigators state as the cause, viz:, that the greater stress thrown upon particular muscles during occupation determine the seat of the microscopical haemorrhages in the nerves supplying the muscles or in the muscles themselves, thus causing the paralysis to effect just those muscles as have the increased strain thrown on them, and this strain it is which causes the smaller branches of the arterioles and venioles,whose walls have degenerated,to rupture and give rise to the minute haemorrhages. Such muscular paralysis may develop suddenly without much warning. Thus, a worker may be examined and passed by the Factory Surgeon as satisfactory, and develop the paralysis within 24 hours after. The paralysis may be preceeded with pain in the affected part, but often this is not so.

The forms ofparalysis are divided into several types, viz:-

(1) The Anti-brachial (Dejerine-Klumpke) Type, where the muscles of the forearm and fingers - Extensor Communis Digitorum, Extensor Indicis and Extensor Minimi Digiti - are affected, causing the characteristic drop wrist and flexed fingers.

(2) The Brachial (Duchenne-Erb) Type, where the muscles of theupper arm and Supinator Longus are affected.

(3) The Aran-Duchenne type, where the muscles of the Thenar and Hypothenar emmenences and Interossei are

affected. It may be found combined with the Anti-Brachial, and this is the commonest form found.

(4) The Peroneal type affecting the lower extremities, chiefly the peroneal muscles and extensors of the toes. It is the rarest type in adults, but is common in young children in whom these muscles are the ones most exposed to fatigue.

The ocular muscles may also become paralysed, especially the External Recti causing Diplopia, though this too is an uncommon form of paralysis.

Nerve changes in the eye itself are commoner. Optic neuritis or neuro-retinitis sometimes with haemorrhages may take place, due either to a central origin, or secondary to renal changes brought about by the lead, and the patient may become partially or totally blind.

Kidneys. Cirrhosis of the kidneys is a condition often found in workers who have been employed for a long time among lead compounds, and who may or may not have had an attack or attacks of acute lead poisoning. It is always the chronic form of cirrhosis that is found and much discussion has taken place as to whether it is due to an interstitial or parenchymatous nephritis. The kidneys form a channel of excretion for lead salts, though lead is rarely found in anything but small quantities in the urine, and it has been stated that the irritation of the lead on the delicate cells of the glomeruli and tubules set up a condition of cloudy swelling with degeneration of these cells and albuminuria.

Oliver and others say that they have found this parenchymatous degeneration present. On the other hand other investigators state that the change is an interstitial one, and is due primarily to changes in the bloodvessels and the majority of the observers agree that arterio-sclerotic changes are found in the kidneys. The element of alcohol, however, here comes in prominently to complicate matters. From a mistaken belief that beer and spirits help the elimination of lead from the system, alcoholism is fairly common among lead workers at the present day, though in latter years there has been a marked improvement shown over past years, and the cirrhotic changes found post-mortem in the kidneys of a lead worker are very similar to those found in the kidneys of chronic alcoholics, and I believe that the pathological changes produced in the kidneys of lead workers are due as much if not more to the toxic effects of alcohol as to lead, though this could best be proved by a series of autopsies on the bodies of lead workers, both those who were well known alcoholics and those who were known to be abstainers.

Circulatory System. The pulse of a patient suffering from an attack of lead colic is markedly slowed, being as low as 40 or even lower per minute. The tension is raised as shown by spygmographic

tracings and with the Sphygmomanometer the pressure will be found to be increased to 140-170 m.m. Hg. As the acute colic passes off the pulse rate gradually increases towards normal and the tension and pressure gradually lower. The high tension pulse is found at its maximum in cases of colic, but it can be found to a lesser degree in nearly all workers who have been employed for a considerable time amongst lead.

The Blood. As already stated destructive changes take place in the elements of the blood in lead workers. Anaemia is one of the earliest and most marked signs of lead toxaemia. With a Haldane's Haemoglobinometer I have found the haemoglobin content in old lead workers of many years varying from 40-80%, and these men were still quite fit for their ordinary duties.

Stained specimens of blood, as first demonstrated by Ehrlich in 1880, show basophile staining in the red cells, though this has been shown not to be a characteristic feature of lead toxaemia alone, as it may be found in other serious forms of secondary anaemia. There is a diminution in the number of red cells and there are present microcytes, macrocytes and poikilocytes. Little change is found in the white corpuscles, when these are affected it is shown by some increase in the number of lymphocytes and large mononuclear cells with a decrease in the polymorphonuclears.

The Bloodvessels. The evil effects of lead on the bloodvessels of workers in lead is steadily being more appreciated, and gradually it is becoming more evident, that much of the havoc wrought by lead on the system of the workers is caused primarily by the changes it produces in the bloodvessels, as the result of it circulating in the blood stream. During the early years of the lead worker's life, little change can be noted in his arteries, but amongst those operatives who have worked continuously for a number of years in lead, arterio-sclerosis is a common and marked sign. This is evidenced during life by the thickened artery under the palpating finger, by the high pressure registered by the Sphygmomanometer, and by the tendency of lead workers to cerebral haemorrhage and renal disease. Post-mortem it is seen histologically by the thickened walls with degeneration of the muscular coats of the arteries and arterioles in all parts of the body. The bloodvessels thus lose their natural elasticity, becoming closed in some places by obliterative arteritis, and in many place rupturing and causing haemorrhages. Legge and Goadby, in their experiments on animals poisoned by lead, have shown that these haemorrhages, usually minute, were always found post-mortem, and that they were most marked in those parts which

showed the toxic effects of the lead during life. This close co-relation of clinical facts and pathological changes cannot be overlooked, and these minute haemorrhages may easily account for many of the signs and symptoms of Plumbism quoted above. Certainly from this hypothesis most of the signs and symptoms seem more clearly explained than they have been previously.

Sexual Idiosyncrasy. There is a marked sex idiosyncrasy in lead poisoning, women being much more susceptible to it than men, and showing it in more evident and serious ways. So marked is this idiosyncrasy, that the Home Office deemed it necessary to prohibit women from working in the more dangerous parts of the lead industries. Thus, in the manufacture of white lead, women are not now allowed to be employed in the white beds or stoves.

The chief disturbance is in the menstrual function. Amenorrhoea in some, menorrhagia and dysmenorrhoea in others are common symptoms among women workers, and a woman lead worker, becoming pregnant and still continuing at her work, is almost certain to abort or miscarry or if she does produce a living child, it is usually weakly and small and survives only a short time. This abortifacient property of lead has given rise to the popular use

of it in the form of diachylon to produce abortion. The circulating lead in the maternal blood stream undoubtedly is the cause of this, and here again it may be due to the irritating and contractile effect of lead on unstriped muscle fibre, in this case on the uterus. Moreover lead can be transmitted through the placenta to the foetus, killing it in utero or causing it to die after birth. Lead only produces this effect while it is being absorbed, and a female lead worker if she leaves the lead works and thus the source of absorption, will on becoming pregnant carry the child to full time and have a healthy baby. A good example of the effect of lead in this way is shown in the following case:-

Mrs. Gibbons had two children, full time and healthy, when her husband was taken ill and was incapacitated from work for a lengthy period, During this time she obtained work in the Tyne Lead Works. When about 3-4 months pregnant with her third child I had her stopped from working at the Lead Works. This child was born alive, as was a fourth child. Then she again commenced work in the lead works, when she had four abortions all about 3 months with about 6 months between each one. Her husband then died and after a widowhood of 3 years she married again but continued to work at the lead works. Again she had 2 abortions

each about the 3rd month with about 4 months between. She is now 36 years of age and still working. During her employment she was chiefly in the wash-house washing the overalls of the other employees, excepting one short interval when she was engaged among the bark. This case very forcibly brings out the connection and malign influence of lead on women during pregnancy. This woman's first 4 children were carried and born with the woman away from the lead works, (excepting the 3rd child with which she worked the first 3-4 months), and all four children are today alive and healthy. All her subsequent pregnancies while she was employed at the works being prematurely terminated by abortion.

The same detrimental effect on their offspring has been said to befall male lead workers, but investigation at the Tyne Lead Works failed to show this to be the case, the percentage of abortions in the families of the male workers comparing not unfavourably with the general populace.

Case 1. Wm. Quin, 50 years of age. Worked at Tyne Lead Works for a period of eight weeks only, made up of 3 weeks at the "grinders" and 5 weeks at the "dollies" (conveying the massicot after washing to the furnaces). He developed at the end of this 8 weeks an attack of lead colic. When he was seen by me he presented the typical saturnine cachexia, was pale and haggard

looking, with dirty yellow conjunctivae. His gums showed well marked blue lines, on both upper and lower jaws, most of his teeth were in a decayed condition with retracted gums with raw inflamed edges. His breath had the characteristic sweetish disagreable odour. He was in bed lying with his legs drawn up, pressing his thighs against his abdomen shouting out during the paroxysms of pain. The pulse was 52 per minute, hard and full. Very little urine had been passed for the previous 24 hours, when he first took ill, and he was very constipated not having had his bowels moved for 4 days. There was marked tenderness on digital pressure over the descending aortic region, and his wife stated that he vomited up almost everything he took. Under treatment the constipation was overcome, the vomiting ceased, he passed urine in greater quantities and less concentrated. The colicky pain disappeared and in a week he was able to be out of bed and walking about, free from pain and taking his food well. On questioning him I then found that he both smoked and chewed tobacco, doing the latter freely at the works where smoking was prohibited. The tobacco (brown twist), he kept in his vest pocket and he frequently took it out when he wished to bite a piece off to chew. He admitted that he did not trouble much to clean his fingers at these times,

unless by rubbing them on his overalls. His foreman also told me that he was anything but a clean worker. At the end of one month he was allowed to restart in the yard away from the lead altogether, and warned that on the first occasion on which he was found chewing tobacco he would be dismissed.

Case 2. Mrs. Hind. Aged 20 years. She was seen by me with my colleague Dr. Inglis at the request of her husband who stated that she was losing her eyesight and yet did not want to see a doctor. At first unwilling, she afterwards allowed us to examine her, when we found that she had very defective vision, in fact was almost blind, with paralysis of both External Rectus muscles especially of the right eye and internal squint. She complained of severe headaches and had a very well marked blue line on the gums. She had no vomiting and no colic. Her temperature was normal and her pulse abour 60 per minute. After much circumlocution we got from her that she had eaten one out of three pills which she had bought in order to induce abortion. With the ophthalmoscope she was seen to have double neuro-retinitis with slight atrophy of the discs. Next day she was seen in consultation with Sir Thomas Oliver who confirmed all the above and had her removed to Newcastle Royal Victoria Infirmary, where, however, she proved a very refractory patient,

demanded her discharge after a few days there and was lost trace of by me.

I had one of the pills examined and found it contained oleate of lead (diachylon). Whether she has swallowed only one pill or a few I could not discover, but I certainly found that little credence could be put on anything she said.

Case 3. Henry Kidger. Aged 61 years. Married. Has worked in Lead Works almost continuously for 35 years. Had an attack of colic 33 years ago when working in the stoves. For the last 18-19 years worked at the separators. In April 1914, while working at the separators, he experienced a prickly painful feeling in both arms and hands, and felt a distinct loss of power in both upper limbs. Thinking it of little consequence he took no notice of it for a day or two and continued at work, but finding it getting worse, he ceased work and came to see me. When last examined by me in the weekly routine examination of all the employees, he presented no unusual appearance. Now, however, he seemed paler with dirty yellow conjunctivae, and a marked blue line on the gums at the base of his four remaining teeth. He had no vomiting or colic but was very constipated. His upper limbs showed a general appearance of wasting though not marked, and the thenar and hypothenar.

eminences were rather flatter and softer than normal. There was a distinct loss of power in both limbs, raising his arms above his head with difficulty, supination and pronation were fairly good, but his hand grip was very weak. With the dynamometer it measured :-

Right hand 15.

Left hand 20.

He was at once put on treatment, but for the first 10 days the paralysis in the arms and hands got more marked, especially in the right arm and hand, and the muscle wasting seemed to be much more apparent, particularly the muscles of the thenar and hypothenar eminences and the interossei. The dynamometer now registered his grip as:-

Right hand 10.

Left hand 16.

He was now unable to raise his hands and arms to wash his face, to button his clothes or even to feed himself. The paralysis was now seen to be a combination of the Brachial, Antibrachial and Aran-Duchenne Type presenting the following appearance. The fingers especially the ring and little finger of each hand were flexed into the palm with the thumbs straight. The hand was flexed almost to a right angle on the forearm and deflected slightly to the ulnar side. The forearm was carried bent on the

upper arm to a half right angle and half pronated. He was quite unable to extend the fingers or to straighten the hand on the forearm at the wrist. Supination was hardly possible though he could straighten his arm at the elbow. He was unable, however, as stated to raise his arms above the level of the shoulder or put his hands up to his face.

All the muscles responded to the Faradic Current but not to a marked degree.

Under treatment which included the Faradic Current daily he slowly showed improvement, and after about 3 months he could feed himself and wash his face, though he was still unable to button his clothes, and his grip was still weak.

Right hand. 18.

Left hand 30.

At the end of another three months there was still some improvement. He could now button his clothes though slowly and with difficulty. He could straighten his fingers out a little more, though they still remained, especially the ring and little fingers, partly flexed into the palm, and the hand partly flexed on the forearm. About October 1914 (about 7 months from onset) he had still improved and the dynamometer now registered.

Right hand. 22.

Left hand. 36.

At this time he commenced a course of electrical baths as recommended by Oliver and Clague, and on November 11th the manometer registered.

Right hand. 25.

Left hand. 40.

The measurements of the forearms were:-

Right { just below elbow.....10 inches.
at wrist. .... 6½ inches.

Left { just below elbow. ....10¾ inches.
at wrist..... 6⅞ inches.

The arm and hand of the left side was better than the arm and hand of the right side.

After 15 baths, 28th Jan. 1915. dynamometer gave:-

				Right hand.	32.
				Left hand.	40.
"	20	"	11th Feb.	"	Right hand.	34.
				Left hand.	44.
"	30	"	12th June	"	Right hand.	36.
				Left hand.	48.

and measurements of forearm now were:-

Right { just below elbow.....10¼ inches.
at wrist..... 6¾ inches.

Left { just below elbow.....11 inches.
at wrist..... 7 inches.

At this time Kidger was looking very well, had put on 1½ stones in weight and stated he felt very well, and for the previous two months had been desirous of of resuming light work. He had fairly good use of his hands and good strength in his arms in weight lifting as high as the shoulder, but his power was much weaker above the height of the shoulder.

One month later, July, he started work doing light jobs about the yard away from the lead entirely, and he manages to get along quite comfortably, though there still remains some permanent paralysis in the arms and hands.

Case IV. George E. Dalton. Age 36 years. Occupation - Plumber. History:- He returned from work on Friday night Nov. 27th 1908 with a severe headache. The headache lasted all night and he went to work the next day still unwell and feeling giddy. He fell down at work and had a slight convulsion recovering after about an hour. After walking about all day until night he was seized with another convulsion of his arms and legs. He became unconscious and was carried home.

Previous History:- He was treated for Iritis at the Newcastle-on-Tyne Eye Infirmary at the beginning of the year. First one eye was affected and then the

other. The patient was first treated with Salicylate of Soda and then with Iodide of Potash. A month ago he went to the Eye Infirmary because his eyesight was failing him.

Present condition:- The patient was unconscious. He still showed conjunctival and skin reflexes when a needle was introduced into his skin. The knee jerks were present on both sides. The right arm and right leg were rigid and motionless. The left arm and left leg moved rather convulsively. There was a Babinsky sign on the right side, flexor response on the left side. Sensation as far as could be told was normal. The eyes had a tendency to look to the right.

On ophthalmoscopic examination marked optic neuritis was found on the right side, less marked on the left side. The Abdomen was normal and not at all tender to the touch. In the mouth, the teeth were clean, but with a blue line around the roots of the upper incisors. The patient had control over his faeces, but passed them into the bed when he had the desire. The same applied to the urine. The urine had a Sp. Gr. 1020, was acid and without sugar or albumen. The heart sounds were normal and the arteries not thickened. The blood pressure was 105 m.m. Hg. Lungs were normal. The patient remained

in the above condition until December 3rd, when he became more unconscious and vomited, getting gradually worse and died soon after midnight on December 4th.

This was a very obvious case of Acute Lead Encephalopathy with marked brain symptoms and practically hopeless from first being seen.

PREVENTION AND TREATMENT.

As a preliminary to taking up the methods of Prevention and Treatment of Lead-Poisoning, it is advisable to study briefly the ways in which lead enters the system. It is now practically agreed that it cannot enter to any very appreciable extent through the unbroken skin, and that the two main channels of entrance are through the Respiratory and Alimentary systems. The relative importance of these two is disputed. Oliver and others emphasize the Alimentary System as the chief channel of entrance and absorption, through the patient swallowing some of the lead compounds. Goadby, on the other hand, in his very convincing experiments on animals showed that the Respiratory Tract was the more important channel, and that workers in lead compounds contracted Plumbism chiefly through the inhalation of lead dust in the air. I have no doubt that both paths play an important role in the production of plumbism, but the bulk of the evidence seems to me to agree with Goadby in that the Respiratory System is the source of greater absorption. It has always been and still is those processes in which most lead dust is thrown into the air, that are the most dangerous parts of white lead manufacture, and under such conditions the worker must inhale a

great deal of the dust in the air, and in practice it has been proved again and again, that the greater the exposure to lead dust the greater is the number of cases of Plumbism. The method adopted to combat this effect of lead dust in the air is to keep the lead compounds in the various processes through which they pass in a wet condition, and by this means the number of cases of lead-poisoning has been markedly reduced. If the alimentary tract was the chief channel of entrance and absorption, one would imagine that this "Wet Method" would not have much effect in reducing the number of cases of plumbism, because the workers would be as likely to swallow lead in the wet state as in the dry, since most lead swallowed reaches the mouth from the dirty fingers of careless employees or by splashing. As we must admit, that the introduction of the "wet method" of white lead manufacture has very markedly reduced the number of cases of lead-poisoning, so we must admit that the presence of the lead dust in the air was the chief cause of these cases, and as lead dust, it must to a great extent have been inhaled.

Knowing that the two important channels of absorption are the Respiratory and Alimentary Tracts, we can now proceed to see how these evil effects may best be combatted.

The way to completely abolish lead-poisoning would of course be to abolish the use of lead and lead compounds, but here we at once meet with many difficulties. For many purposes lead is indispensable, and in these trades where lead compounds are much used and where its dangers have been thus rendered most obvious, viz., the manufacture of china and earthenware, and in the manufacture and use of lead paints, substitutes have been tried but generally found wanting. Leadless glazes have been extensively tried in the Potteries, but though it has been found fairly sucessful in the cheaper class of ware, in the better class of goods it has not proved so satisfactory as the lead glaze, both from a "finish" point of view and from a commercial and monetary standpoint, with the result, that the Departmental Committee, appointed in 1908 to enquire into the possibility of using substitutes for lead in the Potteries, could not recommend the abolition of lead glaze. In a similar way the Departmental Committee on Lead Poisoning among Painters etc., in 1911, found that no complete substitute for white lead had yet been obtained. Numerous substitutes for white lead have been put on the market, but only one or two can come under the heading of competitors, viz., Lead Oxysulphate, Zinc Oxide and Lithopone, and none of these are serious competitors.

Lead Oxysulphate. (basic lead sulphate) is practically as dangerous as Lead Carbonate as shown by Goadby in experiments detailed before the Departmental Committee on the dangers attendant on the use of lead etc., in the Manufacture of Earthenware and China (1910) - p. 49. Appendix XXIV. Vol 11 of their Report.

Zinc Oxide. though shown to have none of the poisonous properties of lead carbonate has been reported on unfavourably by all Master Painters, British and Continental, before the Departmental Committees on Lead Poisoning among Painters etc. 1911. They agree that it is suitable for inside decoration, but for outside work it has not the "covering qualities nor the lasting properties of white lead" and therefore cannot take the place of white lead.

Lithopone a combination of Barium Sulphate 75% with Zinc Sulphate 25% possesses several defects and has never been extensively used alone as a white pigment. Thus we find that no real substitute for lead in the industrial world has yet been found. Experiments may at some time lead to such a substitute being discovered, but meanwhile we have to deal with the continued manufacture and use of white lead, and to endeavour to reduce its baneful influence on the workers, and in the attaining of this object we will find that the essence

of Prevention is summed up in:-

(1) The personal cleanliness of the worker.

(2) The absence of lead dust in the air.

This places the responsibility jointly on the employer and employee and various means have to be taken in order to insure that both fulfil their duties.

Beginning with the workers, all these should be medically examined by the Certifying Factory Surgeon before commencing employment among lead compounds, and those persons showing evidence of tubercular disease, renal disease, alcoholism, bad oral sepsis and in women, pregnancy or history of previous miscarriages, should be rejected, also all persons showing evidence of chronic plumbism, because some of these conditions predispose to acute Plumbism while others are aggravated by working in lead.

When passed as fit by the Surgeon to start work the employee should then be verbally instructed or given a printed notice pointing out the dangers of the occupation, and what steps he or she may take to ensure that the ill effects of lead are not sustained. The importance of carrying out these instructions should be instilled into the worker by the Surgeon and by the Employer or his foremen, and it ought to be the duty of the latter to see that they are carried out. The printed notice should be in plain easily understood language, brief but pointed, so that you may

ensure that the person will read it and imbibe it.

The following may be taken as an example of such:-

LEAD POISONING:- How caused and how to prevent it.

1. Working in lead and lead compounds may be injurious to the health.

2. The chief danger lies in breathing lead dust or fume and eating with unwashed hands soiled with lead, or in putting tobacco pipes or sweets into the mouth or biting the nails while at work.

3. These dangers can be overcome by:-

   (a) Never commencing work on an empty stomach.

   (b) Keeping the hands, face, mouth and clothes as clean as possible. Never to take food without first scrubbing the hands and rinsing out the mouth with water. Use a tooth brush at least once a day.

   (c) Never bite your nails or smoke or chew tobacco or sweets while at work.

   (d) While at work try to avoid the raising of dust and see that the ventilating arrangements for carrying away dust and fumes are in proper working order.

   (e) Overalls when taken off should not be shaken to remove dust and they should be washed at least once a week.

   (f) Constipation should be avoided and Epsom salts taken, (1-2 teaspoonfuls in water)

once or twice a week is a good preventative.

(g) Intemperance greatly increases the risk of lead-poisoning.

(h) See your doctor at once if any of the following symptoms of lead-poisoning show themselves - great constipation, vomiting, colicky pains in the stomach, headache, loss of eyesight, or loss of power in the arms or legs.

These rules require to be strictly enforced, because too often it is from the non-observance of them on the part of the worker that lead-poisoning arises. Chewing tobacco is much too prevalent during working hours, and workers are apt to get careless in the washing of their hands before partaking of meals, and in the keeping down of dust at their work.

A weekly bath should be taken by every worker and the best way to ensure this is to have the baths at the works with a plentiful supply of hot and cold water, soap and brush, and to appoint a certain day and hour for each worker to have his bath. In this way the bathing is spread over the day and over the week, so that a few baths will serve a large number of workmen, and the nature of the man's work can be considered in fixing the day and hour so that no inconvenience is caused to the employer. It is advisable, too, to appoint a man for the men, and a woman for the women,

to look into the baths from time to time to see that the workers actually take their baths, since I have known of men going into the bath room and occupy the time sitting on the side of the bath having a quiet smoke instead of taking their bath. The man who attends to the heating of the water and cleaning the baths can also see that the men really take their baths.

Overalls. All workers in lead compounds should wear overalls and a close fitting cap, both being made of unbleached linen or calico. This prevents them collecting dust in their hair or on their clothing or getting their clothes splashed with wet lead compounds and in the latter condition where workers are apt to get splashed a waterproof apron worn over the overalls is a decided advantage. These aprons can be sponged down each day while the overalls are washed once a week. This washing of overalls is best done at the works where one or two women who can be taught what precautions to take to obviate their contracting plumbism can be employed as washer-women. The overalls should be kept in a suitable room, and another room close at hand should be set aside for the workers depositing the clothes they take off while at work, the walls of both rooms being lined with glazed bricks.

Lavatories. Suitable hand basins (one for every five persons) or troughs with a plentiful supply of hot and cold water, waste pipe, soap, nail brushes and towels should be conveniently placed in a room for the workers, preferably adjacent to, but separate from the dining room and the clothes rooms, and the bath attendant can have charge of the lavatory and see that the basins etc., are kept clean and sweet. Towels should be renewed daily and the nail brushes kept scrupulously clean.

The workers should then on ceasing work at meal hours or at the end of the day, first remove their overalls and then proceed to the lavatory where their hands are thoroughly scrubbed and washed before they are allowed to take their meals or leave the factory. Special soaps and special solutions have been recommended for this purpose, but ordinary soap with a plentiful supply of water and vigorous scrubbing with the nail brush answers the purpose very well.

Dining-rooms. All Lead Works and Factories where lead compounds are used and where dust gets into the air. should be provided with a dining-room for the benefit of the workers where they can have their meals without risk of the food becoming contaminated with the lead. The dining-room should be situated in close proximity to the lavatory and cloak room, so that the workers

can readily doff their overalls and caps, wash their hands and if necessary their faces, before proceeding to the dining room for their food. The room should be well lit, well ventilated, warm and kept scrupulously clean, with provision for warming or cooking the worker's food. In the Tyne Lead Works a female cook is kept to look after this room, keeping it clean and heating the food. As it has been already shown in this treatise that it is one of the important essentials as a preventative against lead poisoning that the workers in a lead factory should not commence the day's work without having had some food, this difficulty has been solved in some factories by the employer providing the workers with hot milk, or cocoa with milk and some bread before they start work in the morning, and this practice might with advantage be made compulsory, since the expense of the breakfast would be saved in the reduced amount of compensation to be paid for lead-poisoning. The best articles of food are those containing plenty proteid and fat. It has been repeatedly shown experimentally on animals, that lead taken with food does not produce signs of poisoning in anything like so short a time as when the lead is taken into an empty stomach. The dining room should be provided with lockers or pigeon-holes for each workman leaving his food, and the room should be of a size compatible with the number of persons who have to use

it. The floor space suggested per person by Reid in his Memorandum on Messroom Accomodation, Potteries Committee's Report Appendix XXV, Vol. II 1910 is:-

for 6 persons and under	-	10½	sq.ft.	per	person.
over 6 persons up to 12	-	7½	"	"	"
" 12 " " " 20	-	6	"	"	"
" 20 " " " 28	-	5½	"	"	"
" 28 and any number	-	5	"	"	"

Workrooms and provision against dust. Much can be done in the arrangement of the workrooms to reduce the risk of lead-poisoning to the workers and this part of the preventative measures lies with the employer. As far as possible different processes should be kept apart and kept to different rooms. In the case of works for the manufacture of White Lead this is fairly easy. Thus the stacks for the chemical transference of blue to white lead can be arranged in a row along one side of a long room, the same applying to the chamber process. The rollers for separating the white from the blue lead can be in another room, the stoves, the grinders and the packing each having their own separate room. The same can be done in the making of red lead, sheet lead and lead piping, and this same separating principle can be carried out in Paint Works, Pottery Works etc., wherever lead is used in any of the processes.

The floors of the work-rooms should be of some smooth and impervious substance such as concrete. With such floors, the dust which collects can be washed down with a hose to keep it clean instead of sweeping it up dry with a brush. Wood and earth floors should be avoided, but large caste iron plates may be used sometimes.

The walls of the rooms where there is likely to be splashing of lead compounds or accumulating of dust should also be made of some impervious material such as glazed bricks,or tiles,or cement which has received several coats of oil paint. In that way they can be washed down with a hose-pipe and water to remove the lead. All ledges, rafters and beams in the roofing where dust collects should only be thoroughly cleaned down at long intervals,as one big cleaning down will probably cause less risk of lead-poisoning than a number of small ones often repeated, and when cleaned the dust can be removed with the minimum of labour by one of the several portable electric vacuum cleaners on the market and with the maximum of safety.

The various processes connected with the manufacture of white lead should as far as possible be worked on the "wet principle", that is,the lead compounds should be kept wet. By so doing the lead dust is reduced to a minimum. The number of stages

in which the lead carbonate can be kept wet is increasing and in some lead works the lead is only dry when it is carried in as blue lead to the stacks, all the other processes through which it passes being carried out on the wet method. It is only dried before finally packing it into the casks, and even then much of it that is to be used for paint is mixed with oil to a thick paste while it is still wet with the water, because it has been shown that lead carbonate has a greater affinity for linseed oil than for water, and in stirring them up together the oil becomes intimately mixed with the lead carbonate while the water separates out and can be run off from the top and the white lead is not adversely affected by this process in the least. In the same way the wet method is followed in the Chamber Process. Where, however, white or red lead cannot be kept wet, and where it has to be handled in the dry dusty state, then efficient exhaust apparatus should be employed to carry off the dust and so prevent it getting into the air around the workers and being inhaled or swallowed by them. Such an exhaust apparatus requires a means for producing a negative pressure, a series of pipes and hoods to draw away the dust, and receptacle to collect the dust in. The means to produce such an exhaust may be one of several.

1. Heat. This may be used as a means of exhaust utilising the up draught of hot air in the factory chimney stack for the purpose. In those processes where lead compounds or lead is subjected to heat as in lead smelting, refining, roasting blue lead to convert it into litharge, and in all the operations where lead is melted either alone or combined with other metals as is done in the making of lead pipes, in tinning, in vitreous enamelling, file hardening and spring tempering, this method of exhaust may be employed by using the heat from the molten metal itself. Over the vessel containing the hot metal a hood is fitted which should entirely cover in the back, and two sides, leaving the front open for the workmen, and this hood should open into a flue which would lead to the chimney. The closer the hood comes down the less will the fumes escape into the workroom. In the case of the roasting furnaces for the manufacture of red lead the hood should project well forward over the furnace door so that the worker, as he rakes the lead about with his long rake, or draws the finished product out into the barrow placed at the furnace door, is protected from the red lead dust, because standing as he does well out from the furnace door any dust arising (and there is always some) gets drawn up immediately into the hood and on into the flues and

chimney at the back of the furnace. This method of exhaust draught by heat, though quite successful in most of the above mentioned operations is not very good for dust alone, as the draught is rather irregular in intensity and often not very powerful.

2. Fans. This method of exhaust ventilation may be produced by two different types of fans.

(a) Low pressure volume or propeller fans.

(b) High pressure centrifugal fans.

The difference in the two types depends chiefly on the arrangement of the fan blades and compared with each other they present certain advantages the one over the other, balanced by certain disadvantages. Either type, however, is quite suitable for the purpose of producing an exhaust draught. They may be driven by a belt and shaft, or by a small electric motor attached directly to the fan. Connected to the fan casing is the duct or flue which should be made of metal (sheet iron or zinc), should be circular in shape, and should be as short and straight in its course as possible. Any bends in the course of the flue should be curved, not a sharpe right angle bend. The diameter of the duct is important and must correspond with the size of the fan and the amount of work required of it. Where branch ducts run into each other the area of cross section of the main duct should

equal that of all the branch ducts combined, and the branch ducts should enter the main duct at an angle of about thirty degrees, never at a right angle, because the latter diminishes the draught by nearly one half.

The hood should be of such a size and shape, and so situated over the work or source of danger, that it sucks in all dust or fumes raised by the worker in handling the material. Where possible the source of danger should be all covered in by the hood, except an opening sufficiently large for the worker to work efficiently. For some purposes this is not possible and then the hood, square shaped or round and contracting in size towards the duct, should be so placed that it controls as completely as possible all the dust which may arise during the process of work. The direction of the draught in the latter cases is of much importance and as far as practicable it should operate below the breathing level of the worker and be directed downwards, or downwards and backwards, in this way best ensuring that the worker inhales none of the dust. The hood ought also to be so constructed that it can pull up and down and so be kept always as near to the source of dust as possible. This is of special significance in the packing or emptying of casks containing dry white or red lead, and in the preparing and mixing paste for accumulator plates etc.

The dust thus collected by the fans must be conveyed to a receiver placed on the far side of the fan. This is usually and best carried out by filter bags made of linen, so that the air can escape through the porous bag and the bag retain the dust, the bag being periodically emptied and the lead dust thus recovered.

All hoods, flues and fans must be kept clean if they are to perform their work efficiently and in the cleaning of them the exhaust draught should be operating and the cleaner should wear a respirator. A free supply of air should always be admitted to the workroom to take the place of the extracted air. A very useful method of ascertaining that the fans etc. are working up to their full efficiency is to periodically measure the draught in the hoods by means of an anemometer.

In some works it has been found possible, by means of compressing air in a series of air-tight ducts and receivers, to force the material in a fine state of division from one place to another and of course this would be the ideal method if it could be applied to all the processes and the risk of dust-laden air would be abolished.

PERIODICAL EXAMINATION BY CERTIFYING FACTORY SURGEON.

All those trades tabulated in an earlier part of this treatise must, according to the Home Office, have the employees periodically examined by a medical man, who is "The Certifying Factory Surgeon of the district or a duly qualified Medical Practitioner appointed by written certificate of the Chief Inspector of Factories", and it is his duty to examine the workers at stated times known to the workers, and keep a record of his examinations in a health register kept by the employer, and no person must be employed without being examined and passed as fit by the Surgeon, or be allowed to work among lead compounds after being suspended by the Surgeon. The rôle played by the Surgeon is an important one - he has to keep a watch on the employees for the danger signals of lead-poisoning, and on these appearing to take steps to prevent actual cases of Plumbism occuring. He must have a fairly intimate knowledge of the various processes carried on at the particular factory and especially of those processes entailing the use of lead compounds, so that if a case of lead-poisoning does occur, he has to see how it has occured, and suggest steps to be taken to prevent others arising. He may also be called upon to treat the person suffering from the lead-poisoning. According to the danger, great or small, of the lead compounds

used in the various factories, the intervals of time between the regular examination varies, thus in White Lead Works the examination must be once a week, in Red Lead Works and those for the manufacture of Earthenware and China, Paints and Colours, Electric Accumulators and Litho-transfers, once a month, in works for Enamelling, Tinning and Chromate of Lead, dyeing of Yarn, once in three months. In the latter cases, however, circumstances may arise, such as a number of cases of Plumbism occurring, when the Chief Inspector of Factories may require a weekly or monthly examination for a time.

At one time the Surgeon made it a point of visiting the works at unexpected times to examine the workers and thus prevent any preparations being made on their part for the examination. This was an excellent reason, but it proved awkward to those employees on night work or who happened to be absent for some reason at that particular time, not knowing the Surgeon was there. As a consequence, the Surgeon now appoints a day and hour when he will be present, and any change of time or date is notified to the works beforehand.

For the purpose of examination a well lit room is necessary and the workers are examined individually. It is difficult to get the average employee to look

upon the examination as for his own benefit and protection, and he is very prone to hide symptoms and try to deceive the Surgeon. Consequently the examination must be chiefly an objective one, and the repeated periodical examinations by the Surgeon allows him to gain a knowledge of the idiosyncrasies of the individual workers, which is of much importance, and then allow for these.

All new starters at the Factory should be brought specially under the notice of the Surgeon at his first visit after their commencing work, and the surgeon should examine them specially as to their general fitness for this particular kind of dangerous work. As already stated, all persons showing evidence of tuberculous disease, renal disease, epilepsy, alcoholism, bad oral sepsis, feeble-mindedness, or evidence of former chronic plumbism together with women obviously pregnant or with a history of previous miscarriages should be at once suspended, as being subjects predisposed to suffer unduly from the effects of lead. Alcoholics are specially prone to contract plumbism. The employer should be taught that the casual labourer should as far as possible be discouraged, and men employed temporarily on some special work such as repairs, extensions etc., should be carefully watched as they do not realise the dangers they are surrounded by. All those new starters passed as fit for the

work should at once be given the leaflet of precautions to be taken, and warned about the danger of neglecting these precautions.

The following may be taken as the routine of such an examination as carried out at the Tyne Lead Works, and typical of what may be carried out at any other Factory where lead is used.

On entering the room and walking towards the examiner the general appearance and gait of the person has to be noticed, special attention being paid for evidence of alcoholic tremor or undue splashing on the workers clothes with lead compounds, showing careless habits in the employee at his work. From the appearance of the face will be seen whether there is much anaemia present. In all workers who have been in contact with lead for some time there is always a certain degree of pallor of the face, partly due to true anaemia partly due to vaso-motor spasm of the arterioles of the face, but if this anaemia is not too marked and not progressive it is not a sign of great importance, certainly not amounting to suspension of the individual. The gait of the person will show, where it is present, the rare form of peroneal paralysis. The eyes give information in regard to the colour of the conjunctivae, ocular muscles and general brightness. Dilated pupils with sluggish reaction of light are often seen in the later stages of lead absorption. The mouth is next

examined and by separating the lips the gums will show the presence or absence of a blue line and the general condition of the teeth and mouth in regard to cleanliness. A brown discolouration of the tongue and saliva will speak of very recent tobacco chewing.

Next the person is asked to stretch out his arms and hands with palms down. The presence or absence of tremor is noted and the characteristic appearance of nails that have been bitten looked for. The condition of the extensor muscles may be ascertained by asking the person to bend his hands backwards and forwards at the wrist only, the arm being still extended with the palm downwards. If there is any commencing paralysis of the extensor muscles there will be in this position marked loss of ability to bend the hand backwards, and in paralysis more marked, even evidence of actual wrist-drop. By requesting the worker to abduct and adduct his fingers from the middle finger the condition of the Lumbricals and Interossei can be ascertained. Another method of testing the Extensor muscles of the wrist and fingers is to ask the person to extend his arms with the palm downwards, then the Surgeon places the palms of his hands on the backs of the man's hands and sees if he can prevent the worker raising his arms from the elbows without bending his wrists and fingers. Any wasting of the muscles

of the thenar and hypothenar eminences is shown by a flattening of these parts of the hand and should be looked for. By these tests any commencing paralysis of the muscles of the forearm and hand can be discovered.

Having completed the objective examination the Surgeon may now ask the person whether he is troubled with headaches or abdominal pains, whether his bowels are regular or otherwise, or any other question he may think fit. The whole examination may be gone through in a very short time, and if it does not altogether prove satisfactory, the man can be stood to one side and examined more carefully at leisure, when all the employees have been seen.

When by such an examination a worker is seen to be suffering from the toxic effects of lead absorption, as shown by marked or progressive anaemia or slight paralysis, he should at once be removed from any further influence of lead and a note made in the health register to that effect. This may mean entire suspension from all work in the factory, or what is more often advisable, unless the person is obviously on the border line of developing an attack of colic or serious paralysis, he should be given work in the yard at some occupation that totally removes him from coming into contact with lead. The place he was working at up

to the time of examination should then be inspected by the Surgeon to see if the man's condition has been brought about through some defect in the preventive measures, that can be remedied. Where total suspension is necessary, and the man is obviously in a condition rendering him temporarily unfit for any other employment,he should for the time he is thus incapacitated be paid compensation.

The record of all these examinations is kept in the Health Register which is divided into two parts:-

Part.I. containing the individual particulars relative to each worker.

Part II being a summary of Part I.

The following gives an example of the regulation register as laid down by the Home Office, and to be kept by every employer of labour where lead compounds are used.

PART 1.

List of Persons Employed in White Lead Processes. Particulars of examination.

No.	Workers name in full.	Process.	First employed in such Process.		Date. Aug 14th Result.	Date. Aug. 21st Result.	Date. Aug 28th Result.	Date. Sept. 4th Result.
			Age.	Date.				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1	Brown, John	Grinders	27 yrs.	12th Sept. 1913	1/A	1/A	1/A	2/A
2	Quin, William	do.	50 "	20th Aug. 1914.	2/A	2/A	2/A	2/A
3	Kidger, Henry	Stoves	61 "	15th Jan. 1915.	2/A	2/A	2/A	2/A
4.	Smith, John Wm	Packing.	35 "	30th Sept 1915	1/A	1/A	2/A	2/B

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PART II.

Reference to Part 1.		Date of examination.	Number of Persons examined.	Particulars of any directions given by the Surgeon. Any certificate of Suspension or certificate permitting resumption of work must be entered here in full.	Signature of Surgeon.
Page.	Coln.				
(1)	(2)	(3)	(4)	(5)	(6).
2	6	14 - 8 - 1915	112	Jas. Parker may resume work at Grinders.	W.W. Inglis
2	7	21 - 8 - 1915	116	Wm Gray to be removed to yard, and only employed there.	W. W. Inglis
2	8	28 - 8 - 1915	113		W. W. Inglis
2	9	4 - 9 - 1915	112	Robt Allison to be suspended altogether.	W. W. Inglis
3	6	11 - 9 - 1915	112		W. W. Inglis

The details in black ink correspond with the printed form, those in red ink, what is filled in by the Occupier (Employer) and Surgeon. It is the duty of the Occupier to fill in Cols 1, 2, 3, 4, & 5, in Part I, while the Surgeon fills in Cols, 6, 7, 8, 9, etc., in Part I. which gives the date of each examination and its result for each worker. All the columns in Part II should be filled in by the Surgeon and in this he also summarises the particulars in Part I.

To make the register an intelligible record to Certifying Surgeon, Factory Inspector and Occupier, and at the same time have full details and yet be simple and easily kept, it is advisable to have a series of symbols for use and this is allowed by the Home Office provided the meaning of the symbols is stated at the commencement of the register.

The following series of symbols will fulfil the requirements of detail and simplicity. A series of numerals and letters are used each having a definite meaning, and the whole being expressed as a fraction such as $\frac{1}{A}\ \frac{2}{A}\ \frac{3}{C}$ etc.

<u>The numerals mean</u>:-

1. Passed without comment (no obvious ill effects of lead).
2. Anaemia, blue line.
3. Marked anaemia, evidence of commencing loss of power in extensor muscles.

The letters mean:-

A. No comment - continues at present employment.

B. Transference of occupation because of evidence of progressive lead absorption.

C. Suspension owing to Lead Poisoning - Colic etc.

D. Suspension owing to other causes than the effects of lead such as Alcoholism, Pregnancy, Renal Disease, Tuberculosis etc.

By this process of periodical examination the Surgeon keeps a watch on the workers, noting from visit to visit the effects of the lead on them, keeping a record of those showing evidence of lead absorption and endeavouring to prevent that condition, unimportant except as a danger signal, passing on to the condition of lead intoxication. Thus in treatment the Surgeon has to deal with:-

(1) Cases of Lead absorption.

(2) " " " intoxication or Lead Poisoning.

In order to prevent (1) developing into (2), steps have to be taken to ensure that the person showing definite evidence of lead absorption shall be provided with means to bring about the elimination of the lead in his system. So long as absorption and elimination balance one another, the individual is not likely to suffer from plumbism, but once absorption begins to gain on elimination then that person is on the high road for an attack of lead poisoning. As the chief

path of elimination is by way of the intestines, it is very essential that constipation must be avoided. For this purpose it is a good plan to keep a supply of some saline aperient in solution at the works under the charge of a foreman, who can give it to the workers as they desire it. A very suitable solution for the purpose is one containing Sodium or Magnesium Sulphate with some dilute Sulphuric Acid and perhaps flavoured with lemon to make it more palatable. Other purgatives in pill or tablet form may be supplied, and the workers should have it impressed upon them that it is very important to prevent constipation, and that these drugs are for that purpose and will be had for the asking.

Then for those persons showing anaemia the Surgeon at his weekly examination can take a note of them and hand it to the foreman who can inform these men that they have to attend regularly each day after meals and get a dose of a mixture, containing iron with some aperient combined. The surgeon thus selects the persons requiring treatment, and the foreman sees that they actually take the medicine.

By such medicinal means, among workmen who have been taught to appreciate them, much can be done to prevent those cases of chronic lead absorption developing into cases of lead intoxication.

In spite of all such precautions, however, cases of lead intoxication will occur, and here again the treatment must be primarily directed towards elimination of the poison, with perhaps special treatment for urgent symptoms, and lastly the promotion of repair to the damaged tissues.

The toxic state shows itself as already mentioned in several ways, the commonest form being that of Colic, in which condition we find the patient in great abdominal pain, very constipated (occasionally diarrhoea) and often vomiting. Lead Colic may present itself in any of the following forms (a) Acute (b) Recurrent and (c) Chronic. The Acute Colic may be very severe, but runs its course in 5 to 7 days, the Recurrent is less severe recurring every 3 to 4 days for several weeks, and is probably due to the irregular excretion of lead by the intestines, the Chronic form is where the pain, referred to the lower part of the abdomen, is always present, though never severe, for 2 to 3 months, and is accompanied by obstinate constipation.

In treating lead colic we thus see that the outstanding symptoms which we have to treat are the pain, vomiting and constipation, and the method of doing this which I have found most sucessful is the following:- In the milder forms of abdominal pain, heat, applied in the form of fomentations, or poultices

to the abdomen is often sufficient, but in the severe forms a hypodermic injection of morphia $\frac{1}{3}$ to $\frac{1}{2}$ gr. may be called for, which relieves the pain and assists in allaying the vomiting. Next the patient is given ½ m. doses of croton oil repeated every 4 hours till the bowels are moved freely, when the croton oil is stopped, and in its place is substituted a solution of Magnesium Sulphate with Potassium Iodide in 5 to 10 grain doses, any increase or extra symptoms as a result of the administration of the Iodide being closely watched for. While the attack of colic persists, and for a day or so after it has gone, the patient is kept on a strictly liquid diet, milk being given liberally, and with advantage 10 grs. of Sodium Citrate may be dissolved in each glassful. Then the patient is gradually allowed back to ordinary food, abstaining from butcher meat for about 10 days longer. Alcohol in any form is entirely prohibited. This method of treatment is generally successful, though where the constipation is very obstinate an enema may be given with advantage to assist the croton oil. By this means the rapid clearing out of the intestinal canal removes all the lead lying in it, and also all the lead excreted into it, and the Potassium Iodide converts the lead in the tissues into a soluble Iodide which is then eliminated into the bowel and so quickly

got rid of. This use of Potassium Iodide however, has to be carried out with care, otherwise harm may be done. Thus, a person having much lead deposited and thus locked up in his system in the insoluble form of lead albuminate, if given big doses of Potassium Iodide, may suddenly have a large amount of soluble lead iodide circulating in his blood stream which may exaggerate the symptoms of the plumbism for which he was given the Potassium Iodide, or even induce a fresh train of symptoms. Thus a case of colic may develop signs of paralysis or even encephal~~itis~~opathy, and Oliver in his book on Lead Poisoning quotes a case where an old lady, suffering from plumbism induced by the use of hair dye containing Acetate of Lead and Sulphur, was given Potassium Iodide in her medicine and suddenly died from the greatly increased toxaemia.

Other drugs may be used in the treatment of colic - for the pain, inhalations of Chloroform or Amyl Nitrite give relief, though only temporary, while Liq. Trinitrini, Sodium Nitrite and Scopolamine though taking longer to act are more prolonged in their action. Also Tanquerel advises the combined use of Belladonna and Opium as being preferable to opium alone in anodyne action. Sodium Monosulphite in ½ to 1 gr. doses three times daily, and Permanganate of Calcium ¼ to ½ gr doses in paraffin capsules,

three times a day, has also been successfully tried.

In the case of the Nervous System where the Central Nervous System has received and is showing the burden of the toxaemia by the epileptiform seizures of encephalopathy, Amyl Nitrite may be inhaled and Bromides given by the mouth or rectum, or lumbar puncture may be performed. The patient should be kept quiet, fed on light nutritious food and the emunctory functions kept active.

For the paralysis of the muscles Potassium Iodide may be given, but with care for the reason already mentioned. Also Iron and Quinine may be given perhaps with Nux Vomica. For the local condition massage with passive movements combined with electricity should be used, the latter either by the Galvanic or Faradic current. In either case the minimum current giving a contraction should be used, and it will be found that a stronger current can be borne in the early than in the later stages. The current should be applied for about half an hour, not longer, at one time and should be done daily. With the galvanic current which is perhaps the better of the two, one pole should be placed in a basin of salt water together with the patient's hand, while the other pole is placed over the affected muscle, and the current should be interrupted about every five minutes.

As the muscles regain their power, graduated exercises should be practised. Where the paralysis is not too marked and got early, and treated as above, the chance of recovery is good. Where, however, the paralysis is severe with marked wasting of the muscles and the treatment delayed, the prognosis is bad.

Oliver and Clague have recently introduced a new method of treatment to extract the lead from the body of the patient by means of electrolysis. A double electrical bath is used, the patient sitting on a chair with his hands in one bath and his feet in another. Into the baths is put a solution of Sodium Chloride in warm water and the negative pole is placed in the hand bath, the positive pole in the foot bath. The poles take the form of aluminium grids. A current of 16 volts and 20-40 milliampères is passed through the baths for about half an hour and the effect is said to be that the lead passes out of the patient's body and becomes attached to the negative pole. Oliver in his book on Lead Poisoning gives statistics showing that measured quantities of lead have been extracted.

My experience of a few cases treated by this method is that distinct improvement follows, but the quantities of lead removed have been so small, that I think the benefit derived from the treatment is as much due to the general tonic effect of the bath as

to the actual amount of lead removed.

The patients treated by this method remark on the feeling of well being they experience immediately after the baths, and the muscular power is greatest I have noticed immediately after they have received the bath, falling off somewhat in a few hours.

PROGNOSIS.

The prognosis of a case of Lead Poisoning depends on:-

1. The susceptibility of the patient.
2. The number of the attacks.
3. The severity of the attack.

Certain persons, as already stated, show a marked idiosyncrasy to lead and develop plumbism quickly and sometimes severely. Such persons, on this trait becoming evident, should be refused employment among lead compounds. Under this heading come of course females and alcoholics. Females contracting lead-poisoning, and this state causing abortion are liable to develop eclampsia, but the Home Office now prohibits them from employment in the more dangerous lead processes. Alcoholics show a marked tendency to develop plumbism, partly due to their inherent carelessness as alcoholics, and partly to the toxic condition and lowered resistance to lead poisoning as to other diseases, induced by the state of chronic alcoholism. Plumbism in alcoholics, too, is less favourable than in those not addicted to alcohol, since the former are more liable to develop the conditions of encephalopathy and paralysis. A person suffering from Chronic Bright's Disease, if he starts work among lead compounds, will have the renal condition aggrav-

ated and then render himself more liable to develop plumbism.

The number of attacks is an important factor in prognosis. A first attack of simple lead colic or slight paralysis is usually recovered from, few such cases ever proving fatal. Where, however, there are multiple attacks, the prognosis becomes less favourable in proportion to the number, as the more severe forms of mental symptoms may supervene. Cases of paralysis affecting the lower limbs (peroneal type) are of more serious import and are apt to become progressive. Acute cases of colic, even if severe, if induced by a sudden large dose of lead and brought under immediate treatment, show generally, practically complete recovery. Cases of encephalopathy, especially if severe, usually prove fatal after running a short course. The insidiously developing attacks of lead poisoning, slowly passing into marked paralysis, or causing Bright's Disease or arteritis are more serious, because the damage is not noticed often till it has become permanent and often progressive.

Much can be done in preventive treatment on the part of employer and employee to prevent sudden and severe attacks of plumbism occurring, and since the Home Office has introduced its stringent rules applicable to all manufacturing processes in which

lead is used, the incidence of such cases has very markedly diminished. The severer types of Lead Poisoning such as Encephalopathy, extensive and permanent Paralysis of Muscles etc, have almost disappeared, and even the milder forms of Colic and Paralysis have been greatly reduced.

In strong contrast to this are the conditions ~~per~~ obtaining in Austria-Hungary, where the Government have never shown much interest or taken steps to enforce precautions against Lead Poisoning. In the pottery districts of Austria and Hungary the workers are allowed to take their work home with them, and this induces the workers to make use of their children to help in the work of "dipping" etc. The result is that Lead Poisoning is rampant in these districts, and numerous cases of abortions and mentally and physically defective children are found. The detection of those cases of Plumbism which develop slowly and insidiously lies with the Factory Surgeon, and it should be his duty at his periodical examinations to recognise these cases early, and by taking the necessary steps to prevent them from developing farther.

Thus the result of all these precautions has made work in lead compounds very much safer than it used to be, as shown by the Home Office Statistics over past years, and although occasional cases of lead-

poisoning will always be met with as long as lead compounds are used in the arts and sciences, I have no doubt but that this improvement will continue to be shown, especially as employers and employees learn to realise the risks associated with the work in lead, and the precautions to obviate these risks are appreciated and strictly carried out.

SUMMARY AND CONCLUSIONS.

Metallic lead together with some of its compounds is of such ubiquitous use that it touches to some extent most people in general, and to a large extent some people in particular, viz., those workers who are employed in industries where it is much used in the production of some commercial product.

For many commercial purposes no real substitute for lead has yet been found.

Lead and many of its compounds used in such commercial products has a highly poisonous effect on living tissues.

It gains admission to the system of the workers by several distinct routes the chief being viz., by the respiratory tract, as fumes or as a fine dust in the air; by the intestinal tract, from the dust in the air or with food, tobacco, sweets etc., contaminated from hands and face soiled with it.

Its toxic effects are shown in certain definite ways viz., Anaemia, Blue line on the gums, Constipation, Colic, Encephalopathy, Paralysis, Arterial Degeneration.

The first three viz., Anaemia, Blue line on gums, and Constipation, of themselves do not constitute

Lead Poisoning in the legal sense. They merely show that the individual is suffering from Lead Absorption, is coming under its toxic effects, but is not incapacitated from work.

The others Colic, Encephalopathy, Paralysis and advanced Arterial Degeneration are distinct evidence of Lead Poisoning and render the person unfit for work of any kind during the time he is so affected, and should be an objection to any further employment among lead or lead compounds after he has recovered from the toxic effects.

Lead Poisoning may arise as the result of:-

1. One or more large doses of lead taken into the body.
2. Small but continuous absorption of soluble lead salts over a period of time.

In the first condition acute symptoms of plumbism soon follow, the person seeks medical advice at once, and under treatment usually quickly recovers, sustaining little or no permanent damage.

In the second condition the damage to the tissue goes on insidiously, the person for a time being unaware of it, until when he does discover that something is wrong, the effects on the tissues may be such that even under treatment complete recovery is impossible, and it may ultimately be the indirect or

or even direct cause of death.

The second condition is, therefore, much more serious and of much greater importance than the first.

The primary and chief effect of lead toxaemia is on the blood and blood vessels, and most of the acute visible signs of lead poisoning such as Colic, Paralysis etc., may be traced to the effects of the lead on the bloodvessels, giving rise to degeneration of their walls, and many minute haemorrhages are found post-mortem in those parts showing most of the toxic effects during life.

There is a marked sexual idiosyncrasy in relation to lead poisoning, females being much more susceptible to its effects than men, and pregnant females being specially liable to be affected by it.

Lead Poisoning can to a very great extent be prevented when suitable precautions are taken. These precautions may be summed up in:-

1. Personal cleanliness of the worker.
2. Absence of lead dust in the air.

The responsibility for these precautions falls on both Employer and Employee, and both ought to carry them out faithfully.

The Employer's part should consist in providing.

Suitable means for preventing lead dust getting into the air around the worker - exhaust fans, "wet method" etc.

Clean overalls for the workers.

Suitable places for bathing and washing.

Suitable accommodation for partaking of meals by the workers.

The Employee's part should consist in

An intelligent understanding of the danger associated with his work, and how it can be over-come by,

Never commencing work on an empty stomach.

Cleanliness (avoiding raising dust, etc) at work.

Personal Cleanliness (washing of hands etc), before leaving work or partaking of food.

Lastly the Factory Surgeon at his periodical examinations should reject those persons unfit for such employment by reason of extraneous causes, (Alcoholism, Bright's Disease, Tuberculosis etc.,). He should note those showing progressive signs of Lead Absorption, have them removed from further contact with lead to prevent them developing Lead Poisoning, and recommend to them suitable Medicine to help to eliminate the lead and to restore their damaged tissues to health.

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